

## CHAPTER 21

### SECONDARY ELECTRICAL DISTRIBUTION

---

#### 21-1. Minimum maintenance activities for secondary electrical distribution systems

For the purpose of this manual the secondary electrical distribution system comprises all components operating at 600 volts and below. The tables located at the end of this chapter indicate items that must be performed to maintain systems and equipment at a minimum level of operational readiness. The listed minimum action items should be supplemented by manufacturer-recommended maintenance activities and procedures for specific pieces of equipment subsystems, or components. Maintenance actions included in this chapter are for various modes of operation, subsystems, or components. Table 21-1 provides information on typical secondary distribution system maintenance. Table 21-2 provides maintenance information for low voltage switchgear, switchboards, and panelboards. Table 21-3 provides maintenance information for transformers. Table 21-4 provides maintenance information for motor control centers (MCC) and motor starters. Table 21-5 provides maintenance information for transfer switches. Table 21-6 provides maintenance information for safety switches. Table 21-7 provides maintenance information for secondary distribution feeders.

#### 21-2. General maintenance procedures for secondary electrical distribution

Typical maintenance tasks should be performed on all electrical equipment as applicable. Inspection frequencies may be increased as required based on observations and experience.

*a. Typical maintenance tasks.* This section presents general instructions for maintaining secondary electrical distribution systems.

(1) Personnel should review past maintenance records to find repair patterns. These records may point to certain components that should be closely inspected during performance of preventive maintenance.

(2) Review operator records concerning electrical load readings; compare with equipment ratings. Operator records regarding operating temperatures and any documented abnormal circumstances associated with the system should also be reviewed.

(3) Secondary electrical distribution equipment should be thoroughly inspected and all discrepancies reported to the shift supervisor.

(a) Inspect to ensure that warning signs exist. Replace as required.

(b) Inspect enclosures for damage, unauthorized openings, and corrosion of metallic objects. Repair and paint as required.

(c) Inspect air passages and remove any blockage.

(d) Inspect, investigate, and solve conditions for unusual odors.

- (e) As equipment is operated and tested, listen, investigate, and solve conditions for unusual noises.
- (f) Inspect electrical connections for degradation and tightness. Repair as required.
- (g) Inspect electrical insulation for discoloration and degradation. Repair as required.
- (h) Inspect equipment grounding components such as conductors and connections. Repair as required.
- (i) Inspect insulators for damage. Replace as required.
- (j) Inspect liquid immersed equipment for leaks and damage.
- (k) Inspect indicating lights for correct illumination.
- (4) Remove debris, dirt, and other foreign objects from all components, housings, cabinets, panels, etc.
- (5) All electrical connections should be torqued to the proper design value.
- (6) Verify operation of space heaters and control thermostat. Check thermostat set point for proper setting.
- (7) Verify the grounding of the equipment and associated neutral where applicable.
- (8) Conduct infrared test on all main current carrying equipment for hot spots that may indicate overload conditions or loose connections.
- (9) Using calibrated test instruments, calibrate ammeters, voltmeters, etc. Verify continuity of metering selector switch contacts with ohmmeter.
- b. Low voltage switchgear, switchboards, and panelboards.* A preventive maintenance plan for low voltage power distribution equipment such as switchgear, switchboards, and panelboards shall include the following activities.
  - (1) Review operator records indicating the number of and causes for breaker operations.
  - (2) Inspect barriers and shutters for physical damage. Prove switchgear shutter operation if possible.
  - (3) Perform insulation resistance test on each phase-to-phase and phase-to-ground using a megohmmeter.
  - (4) Frequency of circuit breaker inspection should be based on the number of operations and the electrical load interrupted during those operations. The higher the number of operations under load, the more often the circuit breaker should be inspected.
  - (a) Inspect drawout contacts for abnormal wear, tension, and discoloration. Correct as required.

(b) Inspect breakers' current carrying components for discoloration that may indicate overheating. Replace as required.

(c) Inspect, operate, adjust, and lubricate mechanical linkages. Replace components as required.

(d) Verify interlocks preventing a closed switchgear drawout breaker from being withdrawn from or connected to the switchgear bus.

(e) Inspect and dress current carrying contacts on air circuit breakers in accordance with manufacturer's recommendations.

(5) Power circuit breakers shall be tested in accordance with the following.

(a) Perform test operations to prove correct actuation of breakers' trip and close components, including spring charging motors, trip solenoids, indicating targets, etc.

(b) Perform contact resistance test.

(c) Perform insulation resistance test on each phase-to-phase and phase-to-ground using a megohmmeter.

(d) Prove circuit breaker operation by actuation of each associated protective device.

(e) Prove circuit breaker operation by actuation of each breaker's manual control switch or handle.

(6) Molded-case circuit breakers shall be tested in accordance with the following.

(a) Perform overcurrent test on critical load breakers to prove correct actuation of breaker's trip and close components.

(b) Perform contact resistance test on critical load breakers.

(c) Prove circuit breaker operation by actuation of each breaker manual control switch or handle.

(7) Equipment provided with alarms should have the alarms actuated by simulating the alarm condition if possible. If operation is not correct, repair and adjust as required.

(8) Using a calibrated test set, all relay and solid-state type protective devices should be calibrated.

(9) With more electrical load equipment using solid state devices containing harmonic producing components like semiconductor controlled rectifiers (SCR), a harmonic analysis should be performed if such non-linear load equipment is connected to the secondary electrical distribution system. This analysis may first be performed with an oscilloscope to determine the extent of harmonics. Should further evaluation be required, a harmonic distortion analyzer should be utilized.

(10) Neutral currents should be measured with a true rms meter to determine load imbalances and identify harmonic currents. A record of the measurements should be maintained for future comparison.

c. *Transformers.* Low voltage transformers are generally of dry type construction.

(1) Inspect solid electrical insulation for discoloration and degradation.

(2) Transformers utilizing forced cooling systems shall be tested as described below.

(a) Inspect forced cooling system equipment for damage, etc.

(b) Operate system and if possible, by simulating high temperature at controlling devices.

(3) Transformers with temperature, level, pressure, pressure relief device, etc., alarms should have alarms actuated. If operation is not correct, repair and adjust as required.

d. *Low-voltage power filters.* See chapter 27 for inspection and testing of power filters.

e. *MCCs and motor starters.* There are many varieties of MCCs and motor starters. The maintenance recommendations that follow can be applied to most product types likely to be encountered.

(1) Inspect MCCs and starters as described below.

(a) Inspect main contacts and auxiliary contacts on contactors.

(b) Inspect pushbuttons, indicating lights, selector switches, etc. for damage. Replace as required.

(c) Inspect indicating lamps for burned out bulbs or improper illumination. Repair as required.

(2) Perform insulation resistance test on each phase-to-phase and phase-to-ground using a megohmmeter.

(3) Frequency of MCC unit inspection should be based on the number of operations and the electrical load during those operations. The higher the number of operations under load, the more often the unit should be inspected.

(a) Inspect drawout contacts for abnormal wear, tension, and discoloration. Correct as required.

(b) Inspect units' current carrying components for discoloration that may indicate overheating. Replace as required.

(c) Inspect, operate, adjust, and lubricate mechanical linkages. Replace components as required.

(d) Verify mechanical interlocks.

(e) Inspect and dress current carrying contacts on switches and contactors in accordance with

manufacturer's recommendations.

(4) Motor starters shall be tested as described below.

(a) Manually operate switches and circuit breakers to verify correct operation.

(b) Operate starter unit using all manual and automatic control devices to ensure correct operation.

(c) Verify correct interlocking action with other associated equipment.

(d) Verify correct indicating light operation.

(5) Equipment provided with alarms should have the alarms actuated by simulating the alarm condition if possible. If operation is not correct, repair and adjust as required.

*f. Automatic transfer switches.* Proper maintenance of automatic transfer switches ensures emergency power will be available to mission critical loads when needed.

(1) Review operator records indicating the number of transfer operations.

(2) Frequency of transfer switch inspection should be based on the number of operations and the electrical load during those operations. The higher the number of operations under load, the more often the circuit breaker should be inspected.

(a) Inspect, operate, adjust, and lubricate mechanical linkages. Replace components as required.

(b) Verify operation of mechanical interlocks.

(c) Inspect and dress current carrying contacts in accordance with manufacturer's recommendations.

(3) Automatic transfer switches shall be tested as described below.

(a) Perform insulation resistance test on each phase-to-phase and phase-to-ground using a megohmmeter.

(b) Perform contact resistance test.

(c) Prove correct operation of the transfer switches by manually initiating transfers in both directions.

(d) Simulate the automatic conditions requiring automatic transfer switches to transfer in both directions. Verify correct operation.

(e) Verify starting of generators where applicable.

(f) Verify correct indicating light operation.

(4) Equipment provided with alarms should have the alarms actuated and if possible, by simulating the alarm condition. If operation is not correct, repair and adjust as required.

g. *Safety switches.* Safety switches are commonly used as a lockout device to de-energize equipment for maintenance activities. As such, their proper operation is vital to providing a safe working environment for maintenance personnel.

(1) Safety switches shall be inspected as described below.

(a) Inspect, operate, adjust, and lubricate mechanical linkages. Replace components as required.

(b) Verify operation of mechanical interlocks.

(c) Inspect and dress current carrying contacts in accordance with manufacturer's recommendations.

(2) Safety switches shall be tested as described below.

(a) Perform insulation resistance test on each phase-to-phase and phase-to-ground using a megohmmeter of each critical load switch.

(b) Perform contact resistance test on each critical load switch.

h. *Secondary distribution feeders.* Preventive maintenance of low-voltage electrical cable and busway installations is critical to ensuring continuity of service to loads.

(1) Accessible portions of cables, especially splices and terminations, should be visually inspected for insulation damage, discoloration, etc.

(2) Perform insulation resistance test with megohmmeter.

(3) Perform busway insulation resistance test, phase-to-phase and phase-to-ground.

i. *Onsite generators.* See chapter 19 for preventive maintenance information concerning generators.

Table 21-1. Typical secondary distribution maintenance

Typical Secondary Distribution Maintenance	
Action	Frequency
<p><b>WARNING!</b></p> <p>MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES.</p>	
Review maintenance records.	2 wks
Review operator records.	2 wks
Inspect equipment for the following:	
Inspect to ensure that warning signs exist. Replace as required.	yr
Inspect enclosures for damage, unauthorized openings, and corrosion of metallic objects. Repair and paint as required.	yr
Inspect air passages and remove any blockage.	yr
Inspect, investigate, and solve conditions for unusual odors.	yr
As equipment is operated and tested, listen, investigate, and solve conditions for unusual noises.	yr
Inspect electrical connections for degradation and tightness. Repair as required.	yr
Inspect electrical insulation for discoloration and degradation. Repair as required.	yr
Inspect equipment grounding components such as conductors and connections. Repair as required.	yr
Inspect insulators for damage. Replace as required.	yr
Inspect liquid immersed equipment for leaks and damage.	yr
Inspect indicating lights for correct illumination.	yr
Clean equipment.	yr
Tighten electrical connections.	yr
Verify space heater operation.	yr
Verify equipment grounding.	yr
Perform infrared test.	yr
Calibrate recording and indicating metering.	yr

Table 21-2. Low voltage switchgear, switchboards, and panelboards

Low Voltage Switchgear, Switchboards, and Panelboards	
Action	Frequency
<p><b>WARNING!</b></p> <p>MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES.</p> <p>SWITCHGEAR BUS INSULATION IS NOT DESIGNED TO PROTECT AGAINST ELECTRICAL SHOCK. CONTACT WITH THIS BUS OR ITS CONNECTIONS SHOULD BE AVOIDED WHEN SWITCHGEAR IS ENERGIZED.</p>	
Review operator records.	yr
Inspect barriers and shutters for physical damage.	yr
Test phase bus insulation.	yr
Service circuit breakers.	yr
Inspect drawout contacts for abnormal wear, tension, and discoloration. Correct as required.	yr
Inspect breakers' current carrying components for discoloration that may indicate overheating. Replace as required.	yr
Inspect, operate, adjust, and lubricate mechanical linkages. Replace components as required.	yr
Verify interlocks preventing a closed switchgear drawout breaker from being withdrawn from or connected to the switchgear bus.	yr
Inspect and dress current carrying contacts on air circuit breakers in accordance with manufacturer's recommendations.	yr
Test power circuit breakers.	
Perform test operations to prove correct actuation of breakers' trip and close components, including spring charging motors, trip solenoids, indicating targets, etc.	yr
Perform contact resistance test.	yr
Perform insulation resistance test on each phase-to-phase and phase-to-ground using a megohmmeter.	yr
Prove circuit breaker operation by actuation of each associated protective device.	yr
Prove circuit breaker operation by actuation of each breaker's manual control switch or handle.	yr
Test molded-case circuit breakers.	
Perform overcurrent test on critical load breakers to prove correct actuation of breaker's trip and close components.	yr

Table 21-2. Low voltage switchgear, switchboards, and panelboards (continued)

<b>Low Voltage Switchgear, Switchboards, and Panelboards</b>	
<i>Action</i>	<i>Frequency</i>
Perform contact resistance test on critical load breakers.	yr
Prove circuit breaker operation by actuation of each breaker manual control switch or handle.	yr
Verify equipment alarms	yr
Protective device calibration	yr
Perform harmonics analysis	yr
Measure and record neutral currents	yr

Table 21-3. Secondary system transformers

Transformers	
<i>Action</i>	<i>Frequency</i>
<b>WARNING!</b>  MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES.	
Inspect solid electrical insulation for discoloration and degradation.	6 mos
Verify forced cooling systems	
Inspect forced cooling system equipment for damage, etc.	yr
Operate system by simulating high temperature at controlling devices.	yr
Verify transformer alarms	yr

Table 21-4. MCCs and motor starters

MCCs and Motor Starters	
<i>Action</i>	<i>Frequency</i>
<p style="text-align: center;"><b>WARNING!</b></p> <p style="text-align: center;">MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES.</p>	
Inspect MCCs and motor starters for the following:	
Inspect main contacts and auxiliary contacts on contactors.	yr
Inspect pushbuttons, indicating lights, selector switches, etc.	yr
Inspect indicating lamps for burned out bulbs or improper illumination. Repair as required.	yr
Test phase bus insulation	yr
Service MCC units	
Inspect drawout contacts for abnormal wear, tension, and discoloration. Correct as required.	yr
Inspect units' current carrying components for discoloration that may indicate overheating.	yr
Inspect, operate, adjust, and lubricate mechanical linkages. Replace components as required.	yr
Verify mechanical interlocks.	yr
Inspect and dress current carrying contacts on switches and contactors in accordance with manufacturer's recommendations.	yr
Test motor starter unit	
Manually operate switches and circuit breakers to verify correct operation.	yr
Operate starter unit using all manual and automatic control devices to ensure correct operation.	yr
Verify correct interlocking action with other associated equipment.	yr
Verify correct indicating light operation.	yr
Verify equipment alarms	yr

Table 21-5. Automatic transfer switches

Automatic Transfer Switches	
<i>Action</i>	<i>Frequency</i>
<p style="text-align: center;"><b>WARNING!</b></p> <p style="text-align: center;">MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES.</p>	
Review operator records	yr
Inspect automatic transfer switches for the following:	
Inspect, operate, adjust, and lubricate mechanical linkages. Replace components as required.	yr
Verify operation of mechanical interlocks.	yr
Inspect and dress current carrying contacts in accordance with manufacturer's recommendations.	yr
Test automatic transfer switches	
Perform insulation resistance test on each phase-to-phase and phase-to-ground using a megohmmeter.	yr
Perform contact resistance test.	yr
Prove correct operation of the transfer switches by manually initiating transfers in both directions.	yr
Simulate the automatic conditions requiring automatic transfer switches to transfer in both directions. Verify correct operations.	yr
Verify starting generators where applicable.	yr
Verify correct indicating light operation.	yr
Verify equipment alarms	yr

Table 21-6. Safety switches

Safety Switches	
<i>Action</i>	<i>Frequency</i>
<p style="text-align: center;"><b>WARNING!</b></p> <p style="text-align: center;">MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES.</p>	
Inspect safety switches for the following:	
Inspect, operate, adjust, and lubricate mechanical linkages. Replace components as required.	yr
Verify operation of mechanical interlocks.	yr
Inspect and dress current carrying contacts in accordance with manufacturer's recommendations.	yr
Test safety switches	
Perform insulation resistance test on each phase-to-phase and phase-to-ground using a megohmmeter of each critical load switch.	yr
Perform contact resistance test on each critical load switch.	yr

Table 21-7. Secondary distribution feeders

Secondary Distribution Feeders	
<i>Action</i>	<i>Frequency</i>
<p style="text-align: center;"><b>WARNING!</b></p> <p style="text-align: center;">MAINTENANCE PERSONNEL SHALL LOCKOUT/TAG EQUIPMENT TO ENSURE DE-ENERGIZATION DURING MAINTENANCE PROCEDURES.</p>	
Perform cable inspection	yr
Perform cable insulation test	3 yrs
Perform busway insulation test	5 yrs